

## THE INSPIRATION DESIGN TOOLKIT: A HUMAN-CENTERED DESIGN TOOL FOR A SYSTEM ENGINEERING COURSE

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### ABSTRACT

*System Engineering education typically includes content to help students learn to design and engineer large, complex systems in a structured way. In this paper, we describe the outcomes of introducing a human-centered design tool, the Inspiration Design Toolkit (IDT), to encourage students to think non-linearly. The IDT is an educational resource consisting of a deck of illustrated cards that contain provocative questions, reflection messages and icons, applicative examples, and key takeaways on microlearning units. The aim of the IDT is to improve the participants' learning experience and course engagement, increase opportunities for them to interact with their peers and teaching team, enable them to practice and reinforce the concepts through the creation of their own IDT cards, and share the cards in the discussion to increase learners' engagement with course material and peers. We designed the IDT for an MIT online course on System Thinking. We collected, analyzed, and synthesized qualitative and quantitative feedback from 171 course participants. Our findings suggest that IDT provides learners with a digital asset that allows them to reinforce and recall the course takeaways, and apply them to other contexts. For future research, we want to understand how learners like and use IDT through demographic differences and preferred self-identified learning styles. We discuss how these findings may help educators consider critical design principles and for creating a digital self-learning toolkit connected to the course content and increasing its content adaptability.*

**Keywords:** System Thinking, Systems Engineering, Systems Design, Design Toolkit, Human-Centered Design, Design Theory and Methodology, Design Process, Education

### 1. INTRODUCTION

Contemporary system engineering courses cover a breadth of engineering knowledge with cross-disciplinary research topics on management, organizations, and other studies in order to teach designers and engineers how to effectively develop and deploy large, complex systems like automobiles, airplanes, and space systems. A common way of teaching system engineering involves a single communication channel that transfers knowledge from professors to students: lecturers share technical content and their own professional experience with students and students receive knowledge from the lecturers. The goal of this study is to integrate a human-centered design (HCD) [1] tool, called the Inspirational Design Toolkit (IDT), to improve students' whole learning experience and enable course participants to engage with the course content, interact with the peers and teaching team, practice through exercise, and enjoy the course learning journey. In the long-term goal, we want to build a more interactive and human-centered learning community by using IDT.

In this study, we apply the HCD process to create assisted creative learning material—IDT (Figure 1), designed for the five-week online course on System Thinking hosted on an Open



design and the IDT toolkit design are influenced by the research of university engineering education.

## 2.2 Creativity Toolkits

There are numerous creative toolkits on the market with different purposes: education, inspiration, methodology innovation, or entertainment. From the 1950s to the 1980s, card-based design tools were produced to stimulate general creative thinking [6]. From the 1980s to the 1990s, there were a few toolkits designed for user participatory process and system design [7]. After 2000, the purpose of the card-based tools is varied ranging from ideation, problem-solving, HCD, to organizational design, and culture cultivation. Among most creative toolkits, there is a potential requirement to verify and experiment with the effectiveness of creativity [8].

In the study, we categorized the landscape of creativity toolkits into three types: 1. The specific problem-solving type, 2. The educational type, and 3. The hybrid type. Toolkits also have various interactive formats such as a series of physical cards, a booklet, a map, a game set, a phone app, and web-based material. The specific problem-solving type is designed to help people solve certain kinds of problems to meet the functional requirements such as Human-Centered Design: Toolkit [9] applied in design projects, IDEO AI Ethics Cards [10] utilized in technology-and-ethic-related issues, The Circular Design Guide [11] used to learn about circular economy, and Design Thinking for Libraries toolkit to tackle issues faced by librarians. The educational toolkit assists users in an educational context to support the problem-solving process, such as Systemic Design Toolkit [12], IDEO Method Cards [13], SYPartners Superpowers [14], KnowCards [15], Design Thinking for Educators [16], and Designing for Public Services [17]. Both types of toolkits can be applied in a hybrid approach, depending on the research purpose, project type, and targeted users (e.g., designers, clients, and educators). Nature Cards [18] is a great example of the hybrid type with a problem-solving tool and supporting material with educational and inspirational purpose. It illustrates how to reveal the hidden events tied to design challenges, which helps discover inspiration for projects.

In summary, there are many creativity toolkits and card-based design tools and apps. But there is no one creativity toolkit that is aimed at a system engineering course, or for entry level to mid-career professionals, or online courses. IDT was created to fill that gap. In the study, we emphasize the hybrid type of design toolkit, IDT, that can trigger participants' curiosity with fresh perspectives to revisit and be inspired by the content in either a physical or virtual card format.

## 3. METHOD

The IDT is a deck of cards that presents a range of HCD prompts to enhance the online and offline learning experience. Its intent is to improve the degree to which course participants engage with the course content, teaching team, and learning community. For example, after participants finish each video segment, the designated IDT card will be shown below to help them review the content by providing key takeaways of the segment and get

inspired by the provocative questions and life-relevant examples. Participants can scan the QR code on the backside of the IDT card to connect to their personal dashboard webpage and course forum with specific segment content to ask questions, share learning outcomes, and download the relevant learning materials. IDT can transform participant's learning experience to be more flexible, engaging, and tailor-made compared to a traditional "professor lecture" type of course format.

In the study, we use the recently launched online professional development course—System Thinking—as a case study to demonstrate the educational value of applying IDT to the course and its comprehensive design and development process. We created a five-minute IDT instructional video [19] to explain to participants the purpose of creating IDT, and the suggested way of how to use it. Each assigned IDT card is presented after participants watch each video segment. Participants can interact with IDT content and scan its QR code to receive further detailed segment information. A complete digital set of IDT cards is provided at participants' personal dashboard webpage for them to download to print or save.

Our study captured feedback on the IDT from 171 learners participating in two course pilots (on a private instance for a specific company, and a public instance). We collected qualitative and quantitative data through concept evaluation questionnaires, comments on the discussion forum, DIY card, and the course exit survey. Results from qualitative data analysis were triangulated against qualitative feedback to better understand learners' experiences [20]. These pilots were 90% final in terms of content development (they contained most of the final actual course videos, exercises, pre- and post-quizzes, and IDT cards paired with the microlearning units designed for the first part of the course: Foundation of System Thinking).

We asked participants about their experiences with the IDT content on a five point Likert scale [21] across five main areas: provocative questions, life-related examples, key takeaways and learnings, supporting visuals, and three assisting reflection icons. For the purpose of research, collected data that not only focuses on an individual IDT card design, but also capture their comprehensive views on IDT as a learning tool. We also encourage participants to discuss course/IDT-related questions on the course forum and empower them to think outside the box to create their own learning creative toolkit. Table 2 shows the two-course pilot test information gained from the MIT xPRO System Thinking course.

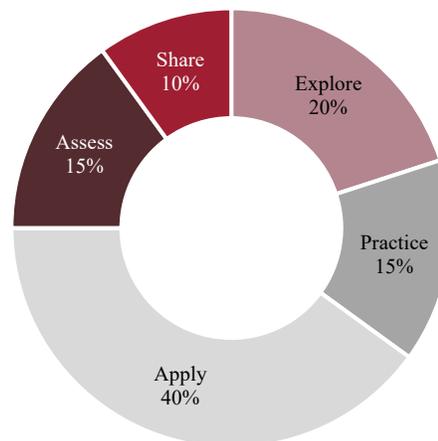
**TABLE 2:** Two-course Runs' Information

	1 <sup>st</sup> Run	2 <sup>nd</sup> Run
Course Name	MIT xPRO System Thinking	
Start Date	Jun 22, 2020 00:00 EDT	Oct 26, 2020 01:00 EDT
End Date	Sep 1, 2020 19:59 EDT	Nov 30, 2020 18:59 EST
Cohort*	Cohort A: 64 participants Cohort B: 66 participants	Cohort: 41 participants

\* Note: The IDT is designed to be applied to the twelve segments of Week 1: Foundation of System Thinking. For the 1st course run, the cohort is designated into two groups for the purpose of A/B testing by using two different design layouts of IDT cards.

### 3.1 Professional Development Engineering Education

In the study, teaching faculty (three professors), teaching assistants (two graduate students), one program manager, and one experience designer started by co-creating a 5-week course content through hands-on activities and real-world applications. Led by course lecturers with the MIT xPRO pedagogical model as guidance [22], the System Thinking course consists of five types of educational activities: Explore, Practice, Apply, Assess, and Share. Explore means students acquire new knowledge by watching videos, and reading material and online tutorials. The practice enables learners to understand whether they understand the theoretical principles and know how to apply them to assess if they acquired the capabilities to solve future challenges. Apply allows participants to estimate problem-solving skills by applying what they've learned from the course through the resolution of real-world-based activities, cases, and a learning simulation. Assess enables participants understand if they acquired the course learning outcomes through various assessment activities. Share is about building connections and sharing students' feedback, knowledge, and experience within and beyond the platform. Figure 2 illustrates the estimated time distribution of the 5-week course for students, which is based on the MIT xPRO pedagogical model.

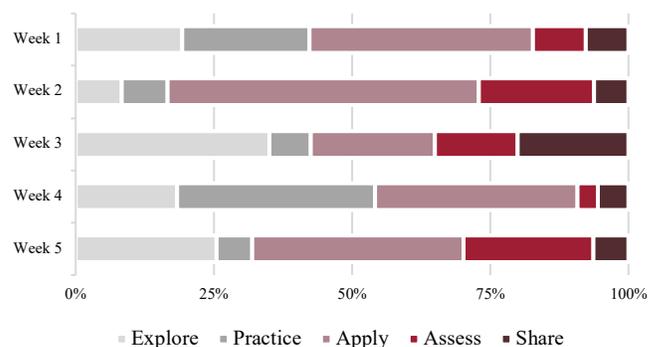
**FIGURE 2:** MIT xPRO Pedagogical Model

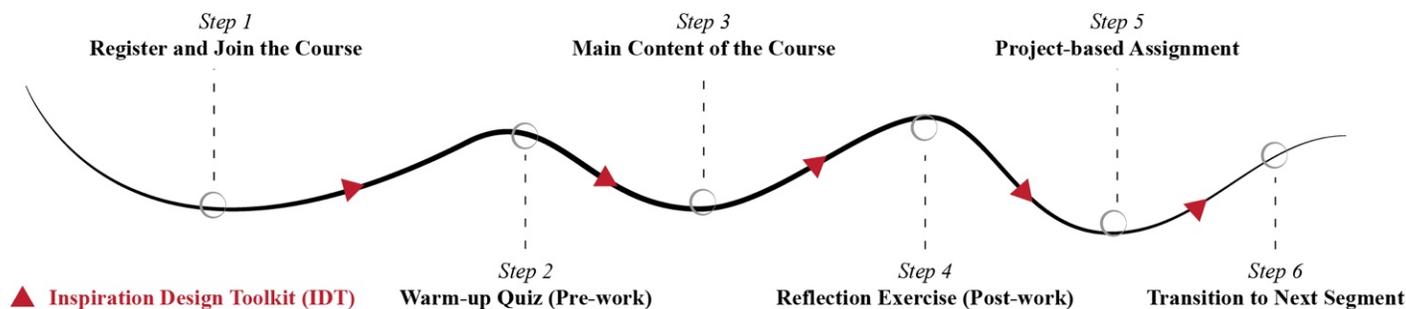
## 4. INSPIRATION DESIGN TOOLKIT AND SYSTEM THINKING

We leverage qualitative and quantitative data from the exit survey, each IDT card, and the participants' interview. These data are triangulated against each other to better understand the participants' experience throughout the course.

### 4.1 Process—Pedagogical Model

According to the MIT xPRO pedagogical model (Figure 2), we planned the estimated learning time distributed into the five types of educational activities including Explore, Practice, Apply, Assess, and Share in a 5-week curriculum design for students (Figure 3). IDT is introduced in Week 1, and then we encouraged participants to apply it to the entire course. We think the "Explore" activity is particularly aligned with the types of activities outlined in IDT cards. In this way, participants' learning experience can be encouraged to make it more delightful, playful, and meaningful to motivate their curiosity about acquiring new knowledge. We hoped that the IDT design can enhance participants' learning experience.

**FIGURE 3:** MIT xPRO System Thinking Course Estimated Time Distribution



**FIGURE 4:** The IDT in Six-step Learning Journey for Participants

## 4.2 Product—IDT Design

IDT is created as part of the curriculum supporting material and is designed to be applied to the twelve segments of Week 1 and Week 2: Foundation of System Thinking out of the 5-week online course. The Figure 5 shows the IDT paper prototype design process. A set of IDT contains twelve double-sided cards. Each IDT card is tied to each segment independently aiming to inspire participants with additional perspectives.

Regarding the design process, the team applies the HCD approach to create IDT by analyzing and mapping out students' normal learning journey map [23] into six steps (Table 3): 1. Register and Join the Course; 2. Warm-up Quiz (Pre-work); 3. Main Content of the Course; 4. Reflection Exercise (Post-work); 5. Project-based Assignment; 6. Transition to Next Segment.

**TABLE 3:** Six-step Learning Journey for Participants

Step	Action
<b>Step 1 Register and Join the Course</b>	Participants need to register the course online and log in the personal participant dashboard.
<b>Step 2 Warm-up Quiz (Pre-work)</b>	There are one to three warm-up quizzes as a preview before participants enter the main content section.
<b>Step 3 Main Content of the Course</b>	This is the main content section of the course presented mostly in video format to participants.
<b>Step 4 Reflection Exercise (Post-work)</b>	Participants need to take one to three reflection exercises related to the course's content as a review.
<b>Step 5 Project-based Assignment</b>	This is a formal assignment of segment, which is consistent and interconnected across the entire course.
<b>Step 6 Transition to Next Segment</b>	Participants are ready to move to the next segment/chapter starting from Step 2—Warm-up Quiz (Pre-work).

Mapping out participants' journey helps us understand their core needs to identify their pain points in the context of the course learning experience [16]. We define for participants all the steps as a typical learning approach rather than viewing it as a uniform, linear learning sequence. The IDT is designed to be applied between each step and to be served as transitional supporting material to connect new segments, help revisit the previous content, and inspire participants through life-related examples and key takeaways. IDT is not intended to be replaced for any of the six steps (Figure 4).

When creating IDT, we have considered: 1. The desirability of participants—The participants' motivation makes them use IDT during the course. 2. Feasibility of technology—Other possible formats (e.g., a virtual app, a set of physical cards, a hybrid learning material of IDT) provided by the course platform that can successfully assist and support participants' learning experience. 3. Viability of business model—IDT is integrated with the course platform to not only create business potential but also bring value to participants. We have also thought about participants' limited attention span for learning and the information hierarchy of IDT. Therefore, IDT is created to consist of five components (Figure 6): Provocative Question, Example, Key Takeaways, Visual, and Reflection Icon in order to meet the requirement of consideration above.



**FIGURE 5:** IDT Paper Prototype Process

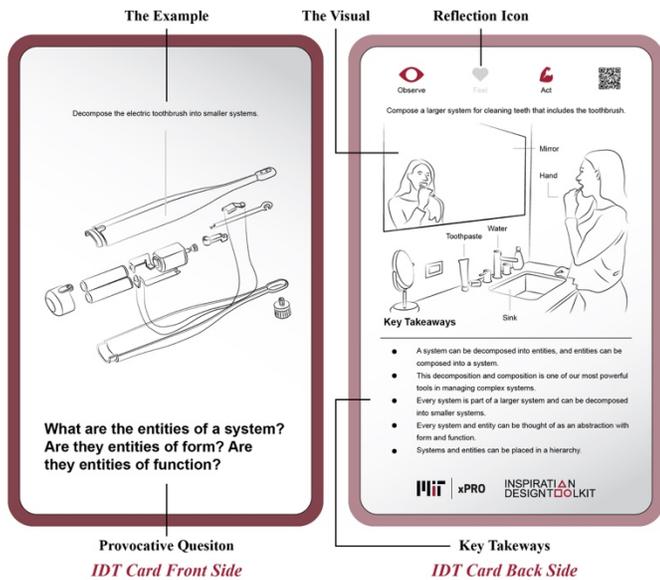
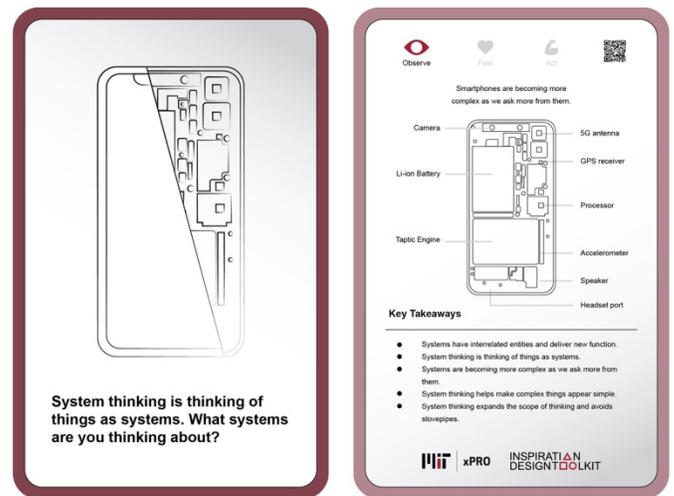


FIGURE 6: IDT Design Layout and Five Components

The Provocative Question serves as an eye-catching segment title for inspiration that matches with the main visual of the life-related examples on the front side of the card. The anchor of the flip side is the Key Takeaways, defined as three-to-five learning points for participants and supported with complimentary visual. Three reflection icons: Observe, Feel, and Act are inspired by the MIT xPRO pedagogical model: explore, practice, apply, assess, and share. The Reflection Icon component is placed on the top of the backside to encourage participants to 1. Observe—Use their mind to see and listen, 2. Feel—Use their heart to understand, and 3. Act—Use their hands to make and prototype. Participants can scan the QR code to connect their personal dashboard webpage which has detailed segment/chapter information.

#### 4.3 Platform—Learning Dashboard

The online course provider (MIT xPRO) has established a personal learning dashboard platform. All registered participants have access to the platform and all the learning materials including IDT. In order to receive participants' feedback during and after the course, we set up four interactive touchpoints embedded in the personal dashboard platform, including 1. IDT Concept Evaluation, 2. Course Forum, 3. DIY Card, and 4. Exit Survey to engage with them. For the IDT concept evaluation, we create a 5-point Likert scale (Figure 7) to evaluate the informative level of twelve IDT cards in terms of five components: Provocative Question, Example, Key Takeaways, Visual, and Reflection Icon ranging from one point (not informative) to five points (very informative).



How informative to you was each of the components from the card?

	Not Informative ← → Very Informative				
	1	2	3	4	5
■ Provocative Question	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
■ The Example	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
■ Key Takeaways	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
■ The Visual	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
■ Reflection Icon	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

FIGURE 7: IDT Concept Evaluation

Participants can post any course/IDT-related questions on the course forum. The teaching team will respond accordingly and recommend relevant resources to participants. We documented participants' quotes and suggestions regarding IDT. Besides verbal feedback, we utilized AWW App [24], an online web whiteboard, and offered IDT card template to empower participants to create their IDT cards virtually. We also created a short exit survey, for example: What are participants' purposes in using the IDT for learning? How do participants interact with IDT? How informative do different parts of the IDT cards seem to participants? Are there other learning toolkit formats that participants prefer to have? In order to capture overview suggestions of using IDT.

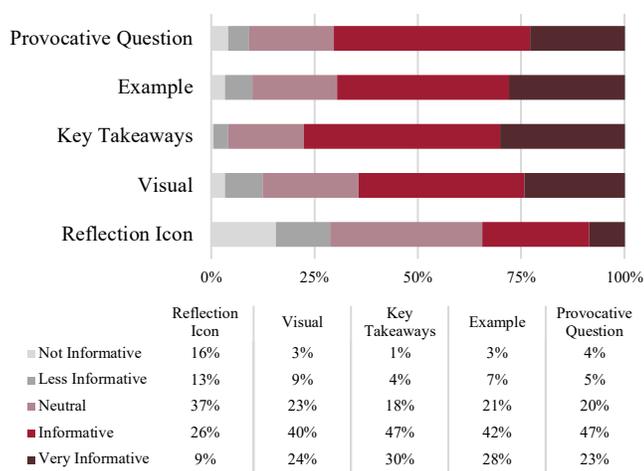
## 5. RESULTS AND DISCUSSION

The following five key takeaways and the study results are synthesized from the student survey, feedback on the IDT from 171 learners participating in two course pilots, discussion and learnings from the three course lecturers, and authors' previous curriculum design experience.

## 5.1 Survey Result Overview

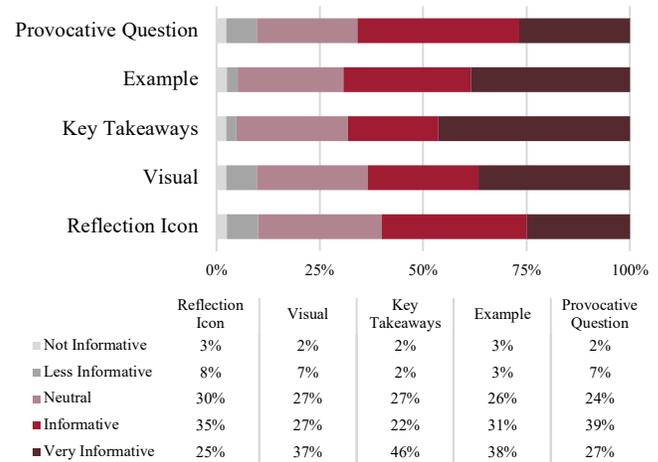
The participants come from engineering-related backgrounds with varied positions and specialties: systems engineers, manufacturing engineers, project engineers, quality engineers, structural analysts, and IT managers. The following comparison diagrams are based on the two-course runs result (Table 2) with different participants accordingly.

As mentioned above, IDT is designed to consist of five components (Figure 6): Provocative Question, Example, Key Takeaways, Visual, and Reflection Icon. Participants think the Reflection Icon component is not a necessary component compared with the other four, since it receives a relatively high percentage on the “not informative” section (16%) for the first pilot test on Figure 8. It also shows the average percentage from the twelve IDT cards, which can view the component of IDT that is helpful for the participants. In general, the IDT is perceived by the participants as informative (40%~47%) learning material for inspiration as well as content revisiting tools. The result of Figure 8 presents that a majority of participants consider the five components “very informative” and “informative”, with most of their percentages combined above 50%.

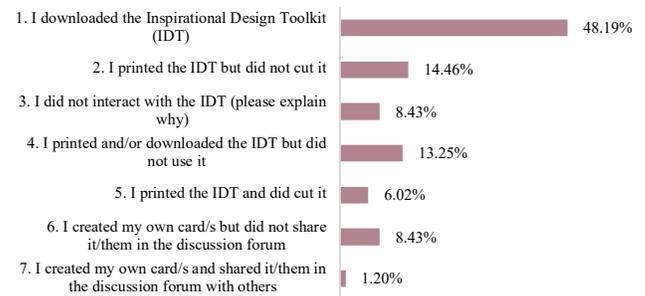


**FIGURE 8:** How informative do the different parts of the IDT seem to you? (1<sup>st</sup> run)

According to Figure 8, the Key Takeaways (30%) and Example (28%) component get the highest percentage indicating that participants consider them as a very informative part of IDT design, while the Provocative Question (23%) and Visual (24%) component get the second highest percentage. The second run (Figure 9) also shows a very similar result. Therefore, we assume that if the component is related to the segment content, participants would be more interested in it and view it as a useful assisting tool.



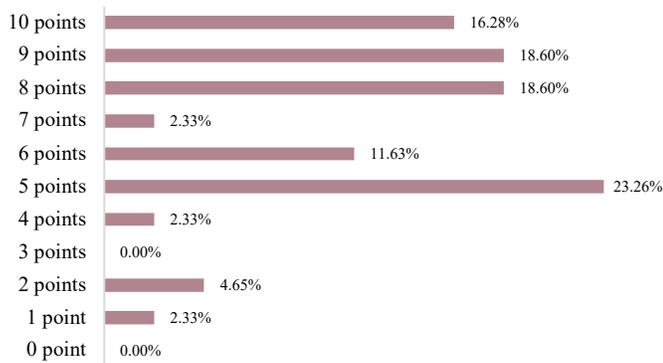
**FIGURE 9:** How informative do the different parts of the IDT seem to you? (2<sup>nd</sup> run)



**FIGURE 10:** How did you interact with this resource? (2<sup>nd</sup> run)

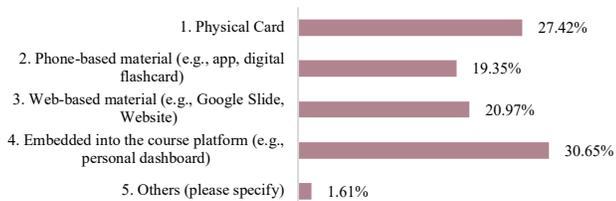
## 5.2 Leverage Features of Different Types of Toolkit Format

According to Figure 10, 48.1% of participants from the second run of the course downloaded the IDT. The intention of the IDT is to assist participants in the course learning experience. The team provided virtual IDT cards so that participants could download it from the course website. What intrigued us in Figure 10 result was the option 5, 6, and 7, since it indicated that participants might still want to have hands-on experience and interact with cohorts and materials by using IDT.



**FIGURE 11:** On a scale from 0-10, how much do you like the IDT? (2<sup>nd</sup> run)

According to Figure 11, participants grading 8~10 points are defined as the group (53.4%) with high interest in IDT and who are willing to try it during the course. “Very interesting material. Excited to learn more and see how lots of this could integrate back into my home organization,” shared one participant on the course forum. We assume that 23.2% of participants grading 5 points don’t show a strong preference for IDT, because this is a fairly new experimental learning format for the course provider (MIT xPRO) in terms of course flow and participant experience.



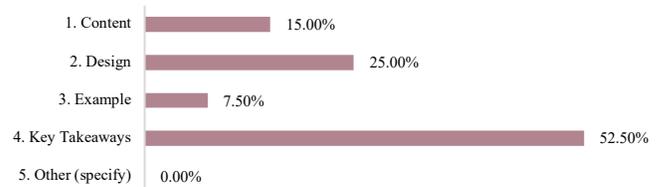
**FIGURE 12:** What other learning toolkit formats would you prefer to have? (2<sup>nd</sup> run)

### 5.3 Use Toolkit Design for Tangible and Virtual Engagement

According to Figure 12, 27.4% of participants prefer to have a physical card format, whereas 30.6% of participants want the IDT embedded in the course platform. If IDT is delivered in a physical set of cards to participants, we assume they can leverage the functionality of cards in a relatively easy way with peers and the teaching team, which echoes the feedback from one participant shared on the course forum “The ‘cards’ are really only useful if they are physical cards that you can flip through.” But some participants also mention that the physical cards might lack accessibility in terms of online peer sharing.

If IDT is created as part of the course content and its platform, we assume participants can apply it to other course learning material seamlessly and thus gain a better and

immersive virtual learning experience. Both options indicate that no matter whether IDT is delivered in a physical format or through a digital channel, participants want to have a well-designed and interactive platform or tools to engage with the course faculty members, teaching assistants, and cohorts.



**FIGURE 13:** Which part of the IDT do you like the most? (2<sup>nd</sup> run)

### 5.4 The Aspects of Practicality and Aspiration of the Toolkit

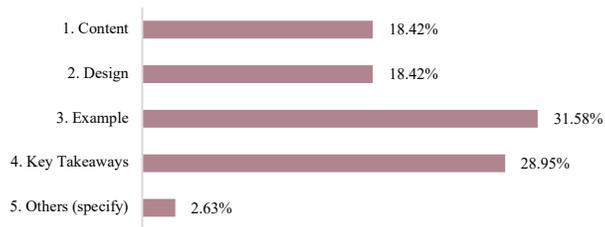
In Figure 13, the brief definition of each option is stated below: 1. Content—The selected provocative questions related to the segment/course content; 2. Design—The overall card layout, illustration, reflection icon, and user experience; 3. Example—The real-life cases connected to the segment/course content; 4. Key Takeaways—The highlights of the segment/course in the format of bullet points.

According to Figure 13, 52.5% of participants like the Key Takeaways component the most and 7.5% of participants consider the Example component useful for them. We interpret the result that participants feel the Key Takeaways component is the most connected to the segment/course content from the aspect of usefulness, echoing one participant’s pain points “I am enjoying the new material and content, however, I still miss having the very clear summary and recap bullet points and cards.” Whereas the Example component of the cards serves more as the inspirational side to revisit the segment content, the content of the Example component is extracted from people’s daily life, intended to be designed in a way that can resonate with participants in a fresher perspective. The challenging part of the life-related example selection is the fidelity of the case. Since participants come from diverse engineering backgrounds with various industry experience, we assume some examples might be obvious or relatively easy for them to understand.

### 5.5 Consider Toolkit Design in the Context of Participant Experience

In Figure 13, the Design component is the second highest (25%) among all components, which reminds us to reconsider the role of design in IDT. In the study, we view design in a broader definition not only by creating appealing icons or graphics but also thinking through the whole participant experience, such as how participants apply IDT to the course content, and how they interact with the lecturers, the teaching assistants, as well as their cohorts. One example regarding participant learning experience design is that we created an IDT instruction video to explain to participants the purpose of

creating IDT, and the approach of how to use IDT properly by themselves. In the lens of the participants learning experience, we should also consider how to use IDT after the course, resonating the feedback we received from participants “I wish we had some reference materials for us to review as we go. Having material like that would come in handy later on when I’d like to reference back to material from the class.”



**FIGURE 14:** What do you want to see more in the IDT? (2<sup>nd</sup> run)

### 5.6 Use Life-related Examples to Illustrate the Concept of System Thinking

According to Figure 14, 31.6% of participants want to see more life-related examples on IDT and 28.9% of participants want to enhance the Key Takeaways component of IDT. The intention of embedding the Example component into IDT is to help inspire participants to come up with interesting ideas through life-related examples in the lens of system thinking. Regarding the example, some feedback was posted on the course forum “I think it’d be easier to engage or employ this thinking with more real-world examples of where this has been used.”, “The examples were extremely relevant, easy to understand and very applicable to personal and professional situations.” and “The examples were clear and gave me new perspectives.” The result of Figure 14 indicates that we can add more life-related examples to stimulate participants for further steps.

As for the Key Takeaways component, participants also wanted to acquire more focus in terms of content. “I like having illustrated examples, but I believe the thought-provoking questions and key concepts could have more of an impact if provided outside of the ‘card’ format.” shared by one participant on the course forum. Since the Key Takeaways component is already a heavily content-driven part of IDT, in the next step we may consider what the best informative approach is to share and organize the segment content that is not limited to the form of bullet points or text and will create an intuitive and visual-impactful way of displaying.

## 6. FUTURE WORK

This study shows preliminary curriculum design, participants’ survey results, toolkit design process, and concept evaluation by applying IDT to an online MIT xPRO course for entry level to mid-career professionals. The goal is to empower participants by using IDT to have a better immersive, delightful, and meaningful self-learning experience as well as to view it as inspirational

material to help participants revisit the course content from various angles. Suggested further research topics cover three directions: 1. Product—How do we scale the influence of IDT by increasing its content adaptability even though MIT xPRO change the course topic? 2. Process—What are the critical design principles and key considerations for creating a digital/physical self-learning toolkit connected to the course content? 3. People—How can we create a comprehensive (e.g., pre-course, in-course, and post-course experience) and human-centered participants’ learning journey by understanding demographic differences (gender/age/level and professional experience) and preferred ways to access the information with the help of IDT?

In the future, we want to investigate whether or not the IDT is also fostering participants to transfer the course knowledge to their real work and we also want to conduct interviews with participants to understand whether they want to apply the IDT for the post-course period and how.

## 7. CONCLUSION

The intent of the study is to apply IDT in the online professional development engineering course to enhance participants’ course experience, to stimulate participants’ learning motivation and curiosity through life-related examples and inspirational materials, with the hope of helping shift engineering educational models and delivery format from traditional in-class learning experience to diverse-and-immersive engineering projects with multidisciplinary interactive activities in the long run [5]. Therefore, we focus on three directions: Process—The co-creation process of the curriculum and IDT design; Product—The key considerations, learnings, and reflection of the IDT product; Platform—Design the IDT in the context of participants’ journey and consider it as part of the course platform system.

- **Process:** In a HCD approach, the system engineering curriculum design and course toolkit, IDT, the creation process is as critical as the outcome. It advocates listening not only to the teaching and design team but also to course participants, to identify pain points and to clarify the key touchpoints through the lens of all the key stakeholders. In short, we need to consider course and IDT design in the context of participant experience rather than purely emphasizing the course content.
- **Product:** We use IDT as a communicative vehicle designed to enhance and increase participants’ engagement with the system thinking course content, peers, teaching team, as well as course community. We also use life-related examples on the IDT to illustrate the concept of system engineering course content and to trigger participants’ curiosity and learning motivation.
- **Platform:** By purposefully utilizing a system engineering course platform, web-based participants’ learning dashboard, we can seamlessly integrate assistant course material (e.g., IDT, videos, links) improve participants’

comprehensive learning experience, enhance the quality of the outcome, and capture participants' real-time feedback. The IDT is not an extension of the system thinking course content. Instead, it is part of the course platform system to bridge the gap between the participants and the teaching team to create a better human-centered learning experience.

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